Development of an Air-Deployable Ocean Profiler

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LONG-TERM GOALS

The Scripps team is committed to expanding the spectrum of long-duration autonomous instruments available for observing the ocean and its processes.

OBJECTIVES

This project's objective is to develop an ocean profiling float, in the style of an Argo float, that can be deployed from aircraft through an A-sized (4.875 inch diameter, 36 inches long) sonobuoy chute. We believe that the availability of aircraft with an A-sized chute capability would allow an air deployable float with multi-month life to provide a unique capability to rapidly establish persistent area surveillance over regions of tens to hundreds of kilometers on a side.

Our initial design target for an air-deployable float is 500-m depth capability, Iridium communication, GPS locating, and 280 dives with a 1000 gm science payload using a 14-D-cell alkaline battery pack, or 450 dives with a 1600 gm science payload using a 10 D-cell lithium primary battery pack.

APPROACH

The task involves minaturizing the technology we have developed for the SOLO-I and SOLO-II Argo floats. In addition to reducing the size to fit the A-sized sonobuoy chute, we are focusing on reducing manufacture cost in a trade-off against the depth capability and the 5-year lifetime of Argo floats.

The design requirements, in order of decreasing difficulty, for a successful miniturization are: (1) minimizing the sonobuoy cannister volume needed to store the drag element (e.g.a parachute) to reduce fall speed during deployment; (2) minimizing the volume of the Iridium/GPS antenna; (3) minimizing the buoyancy change required to raise the antenna high enough to achieve reliable communication; (4) selecting a hydraulic pump for buoyancy change to minimize the combined weight of the pump and batteries required to carry out the pressure-volume work for a complete mission; and (5) selecting materials to reduce a combination of float weight (maximizing payload) and construction cost.

We approach the design issues in three steps; conceptual studies to select the most appropriate technology for each component; sanity check that the selected technolgies can meet the design goals; and detailed design of components based on specified pressure case dimensions.

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WORK COMPLETED

We have completed the first two steps in the design approach described above. Subject to revision when synergy between design elements is understood, our technology selections are:

Reduced fall rate through air. Three options have been studied: rotating vanes (like helicopter blades); ribbon streamers; and parachutes. Rotating vanes promise the greatest drag reduction for a given storage volume inside the deployment cannister but would require unaffordably extensive air testing to perfect attachments and obtain stability during fall. Ribbon streamers involve the simplest attachment, minimize snagging during deployment, and would cause less jerk loading on deployment than a parachute. But the drag coefficient is low, so a substantially greater packing volume is required. Consequently, our tentative selection is a square (to minimize pendular oscillation) 4-shroud parachute made of 0.005 inch nylon. The design target is a fall rate of 14 m/s in a packing volume of 220 cm^3 (around 2 cm of cannister length).

Antenna. In this context the main antenna issue is not the form of the radiating elements of the antenna (e.g. helical, patch, vertical dipole) but the manner of deploying the antenna above the float while minimizing the packing volume. Inflating antennas pack well but were rejected as difficult to maintain in operation after repeated depth cycling over months. Preliminary designs have been developed for two other styles. In one, the antenna is retracted into the pressure case and, after the parachute or equivalent is disconnected from the float, the antenna pops up and locks in place. An alternative is based on a combined antenna and transmission line that is flexible and spring-loaded to extend upwards from the float top cap. This antenna would be coiled into a small packing volume and then released to take its natural shape (like flexible antennas on “rubber ducky” hand sets).

As the antenna is lifted out of the water to operate, its displaced volume must be matched by a volume change produced by the buoyancy engine. The energy needed to raise the antenna depends on the antenna’s volume, which depends on antenna construction and on how high above the surface it must reach. Traditionally, a damping plate provides drag to resist float vertical motion relative to the water, allowing a float on the surface to follow it. We have devised a deployable drag device that in its stowed state is a pair of half-cylinders that wrap the pressure case. In the ocean, these spring into radial positions around the pressure case where they resist relative motion parallel to this axis. An alternative is a damping disk assembled from “whiskers” that fold parallel to the pressure case axis in the deployment cannister and then spring into a radial position once the float is released.

The number of cycles that a float can complete as well as the scientific payload depend on how efficiently stored energy can be converted to pressure-volume work by the buoyancy engine. Two buoyancy engines are under design and prototyping. The smallest, and potentially most energy efficient, is a gear pump designed specifically for this application. It would pump high pressure oil from inside the pressure case into an external bladder to vary float volume. The displacement, 0.08 cm^3 per revolution, is small for an efficient gear pump and tests underway will determine what performance can be obtained. The other buoyancy engine is a single-stroke piston-in-cylinder that pushes directly into the surrounding seawater to change float volume. The gear pump would require auxilliary valves and plumbing while the single-stroke pump, a miniturization of that used in the SOLO-I float, is larger and simpler but requires the piston/cylinder seal to withstand extended exposure to seawater. Only extensive testing will allow us to select the better pump technology and such tests have begun.

RESULTS

Nine months into what we expect to be a three year project, we have identified promising candidate technologies for each of the key design elements. Prototypes for field testing are under construction and preliminary calculations indicate that the design goals for an air-deployed float can be met.

IMPACT/APPLICATIONS

Our immediate goal is to provide a scientific tool for probing the physical structureof the ocean through air deployment of long-lived profiling floats from the most common sonobuoy tube found on Naval patrol aircraft. As such, they could replace AXBTs, with the multiple profile capability allowing maintenance of surveillance for many weeks, while GPS locating and Iridium communication allow the deploying aircraft to be released immediately, at great cost saving over trying to maintain surveillance using single-profile expendables.

Beyond, temperature and salinity profiling, additional sustained ocean measurements, such as acoustic listening, might also be packaged inot a multi-cycle, air-deployed, profiling float.